DEVELOPMENT OF MINI MICRO INJECTION MOULDING MACHINE

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ABSTRACT

The project is to develop a mini micro injection moulding machine. This study consists of three stages which are design concept, fabrication process, and assembly process of the mini micro injection molding that will capable to run similarly as the real industries conventional micro injection molding machine. For the design concepts, two to three injection molding mechanism is designed, compared and choose the best design that can match the requirement of the mini micro injection machine. After the design has been decided, fabrication process will take place. In this project, it is important to define and organize the best and fastest method that suitable to fabricate the machine. Assembly processes need to be done to complete the machine. It consist of assemble the two unit of injection machine which are injection unit and clamping unit. For the last stage, in order to test and function the machine, we need to make it capable to melt the resin plastic and the injection plunger can inject the molten plastic in to the mould cavity through the nozzle.

ABSTRAK

Projek ini adalah untuk membangunkan mesin acuan suntikan mikro mini. Kajian ini terdiri daripada tiga peringkat iaitu konsep reka bentuk, proses fabrikasi, dan proses pemasangan acuan suntikan mikro mini yang akan mampu untuk berfungsi seperti mesin pengacuan suntikan konvensional mikro. Bagi konsep reka bentuk, dua hingga tiga acuan suntikan mekanisme direka, dibandingkan dan memilih reka bentuk terbaik yang dapat memenuhi keperluan sebuah mesin suntikan mikro mini. Selepas reka bentuk telah diputuskan, proses fabrikasi akan dijalankan. Dalam projek ini, ia adalah penting untuk menentukan dan mengatur kaedah terbaik dan paling pantas yang sesuai untuk membina mesin. Proses pemasangan perlu dilakukan untuk menyiapkan mesin. Ia terdiri daripada memasang dua unit mesin iaitu unit suntikan dan unit pengapit. Untuk peringkat terakhir, untuk menguji dan mengfungsikan mesin, kita perlu menjadikan ia mampu untuk mencairkan bahan plastik dan pelekap suntikan boleh menyuntik plastik lebur dalam rongga acuan melalui muncung.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

F	Force
P	Density
V	Volume
m	Mass
r	Radius
L	Length of travel expected of plunger
p	Circular pitch distance of gear
Pc	Diameter of pitch circle
Ω	Angular velocity
v	Injection linear velocity
N	Revolution per minute
T	Torque

CHAPTER 1

INTRODUCTION

1.1 Research background

Injection moulding machine is a machine that always been use in the competitive industries such as automotive industry, electrical and electronic industries, medical industry and etc. Injection moulding machine offers many advantages compare to others manufacturing methods such as minimal losses from scrap due to recycled plastic and minimal finishing requirement. Refer figure 1.0.

Conventional injection moulding machine and micro injection moulding machine has the same purpose which is producing product by injecting process. But what make the micro injection moulding machine is differ compare to injection moulding machine are the specification and parameters that need to control in the micro injection moulding machine. Micro injection moulding is a machine that produces a product that has a weight less than 1 gram and a diameter less than 1mm.

Figure 1.0: Example of injection moulding machine

1.2 Problem Statement

Injection moulding machine in the market is in big size and very expensive in price. It is hard for the small-scale industries especially the industries that forming small or micro plastic product to buy the injection moulding machine due to the costs that can't be afford. Even though the small-scale industries manage to buy the injection moulding machine, the machine still doesn't give a good and reasonable returns compared to the price that been invest. So, the idea of design and fabricate the mini micro injection moulding machine has come out in order to help the industries for production of micro parts where the weight of the product is less than one gram.

Besides that, the mini micro injection moulding machine can be used as rapid prototyping, testing, sample and new product design and development in the economical and practical within the quantities required.

1.3 Research Objectives

In order to develop the mini micro injection moulding machine, there are two main objectives have been identified which are:

I. To design the mini micro injection moulding machine
II. To fabricate the mini micro injection moulding machine according to the decided design.

1.4 Scope of the project

The scope of this project is to design and fabricate a mini version of injection moulding machine, cost effective and environmentally friendly mini micro injection moulding machine for the production of small plastic product that is less than one gram of weight

The mini micro injection moulding machine is simply function by using the electrical motor to drive the injection plunger in order to inject the molten plastic in to the mould cavity. Besides that, the machine also consists of barrel, hopper, nozzle, heater band and others that going to function as the production of micro products.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The micro injection moulding is established as one of the most common manufacturing processes for polymeric materials in micro system technology, especially for thermoplastic resins. Injection moulding is often used to produce large numbers of micro components at a high automation level, and thus at low cost. Complexly shaped micro components with high function integrity are state of the art. [1]

The injection moulding machine processes can be describe as where a granule of plastic material is fed into the hopper that commonly at the top of the machine. The materials are feeds into the barrel that contains a reciprocating screw or a ram injector. The barrel is heated and the reciprocating screw crushes the pallet, making it easier for the material to be in liquid form and has a uniform mixture. The reciprocating screw propels the molten plastic forward and injects the molten plastic through a nozzle and fills the mould. [2]

2.2 Fundamentals of Injection Moulding Machine

2.2.1 Injection unit

The injection unit is responsible for both heating and injecting the material into the mould. The first part of this unit is the hopper, a large container into which the raw plastic is poured. It has an open bottom, which allows the material to feed into the barrel. The barrel contains the mechanism for heating and injecting the material into the mould. This mechanism is usually a ram injector or a reciprocating screw. A ram injector forces the material forward through a heated section with a ram or plunger that is usually hydraulically powered. Refer figure 2.0.

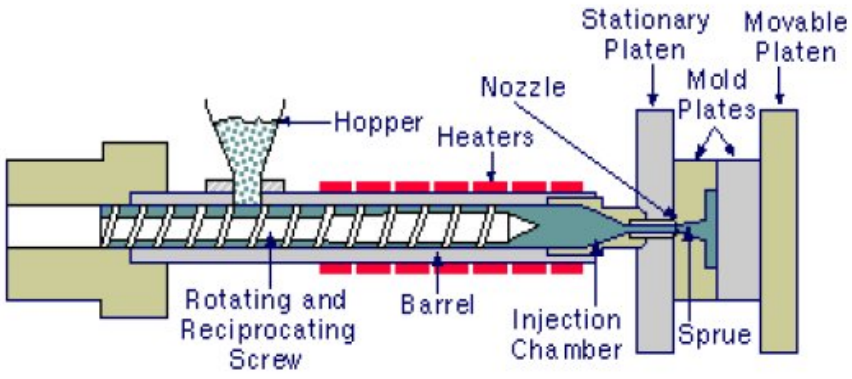

Figure 2.0: Injection unit of Injection Moulding Machine

The injection unit can be divided into several parts which are feed hopper, injection ram, injection screw, injection cylinder and barrel. Below are the description for every parts of the injection unit [3].

I. Feed hopper – the container that commonly in a shape of triangle holding a supply moulding material to be fed to the screw to be heated.

II. Injection plunger/ ram – the molten plastic in the barrel can be fed in to the mould by apply the force or pressure towards the material using this ram or screw.

III. Injection screw – the common screw that use in the machine is reciprocating screw. The function of reciprocating screw is to melt the material and at the same time inject the molten plastic into the mould.

IV. Barrel – the major section that functions to melts the plastic material that transfer from the hopper. Barrel has a control system that can control the suitable and proper temperature to meet the plastic characteristics and get the best uniformity.

V. Injection cylinder – Injection cylinder is composed of cylinder body, piston, and piston load. Hydraulic motor located inside bearing box, which is connected to injection cylinder load, rotates screw, and the melted resins are measures at the nose of screw.

2.2.2 Clamping unit

Prior to the injection of the molten plastic into the mould, the two halves of the mould must first be securely closed by the clamping unit. When the mould is attached to the injection moulding machine, each half is fixed to a large plate, called a platen. The front half of the mould, called the mould cavity, is mounted to a stationary platen and aligns with the nozzle of the injection unit. The rear half of the mould, called the mould core, is mounted to a movable platen, which slides along the tie bars. The hydraulically powered clamping motor actuates clamping bars that push the moveable platen towards the stationary platen and exert sufficient force to keep the mould securely closed while the material is injected and subsequently cools. After the required cooling time, the mould is then opened by the clamping motor. An ejection system, which is attached to the rear half of the mould, is actuated by the ejector bar and pushes the solidified part out of the open cavity. Refer figure

Clamping unit consists of injection mould, injection platens, clamping cylinder and tie bar. Below are the descriptions for each parts of the clamping unit. Refer figure 2.1

I. Injection mould – the mould is the part where the molten plastic is injected to fill the cavity in the mould.

II. Injection platens – the section where the mould is attached. Commonly there are two platens are used which are fix halve and movable halve. The cavity side of the mould is attaching at the fix platens while the core side of the mould is attach at the movable platen. The platens consist of several holes so that the mould can be mounted using clamps.

III. Clamping cylinder - A device that actuates the chuck through the aid of pneumatic or hydraulic energy.

IV. Tie bar – it function to support the force of the clamping. Generally, there are four tie bars located between the fix platen and movable platen.

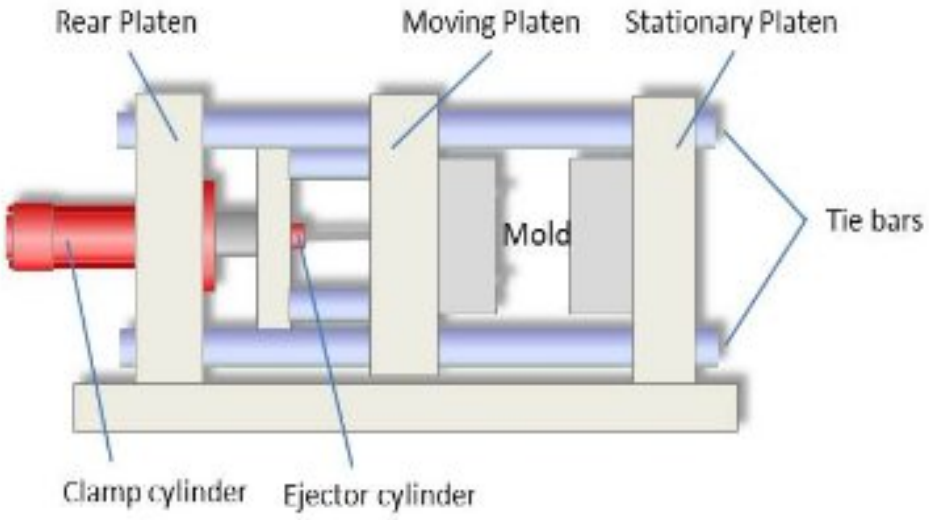

Figure 2.1: Clamping Unit of Injection Moulding Machine

2.2.2.1 Clamping mechanism

The clamping mechanism opens and closes the mould (preferably rapidly) as required during the cycle. It must also supply the necessary clamping force to keep the mould closed during injection, because the injection pressure acting on the internal, or projected, surface of the cavity space tends to open the mould at the parting-plane or parting line. [4]

2.2.2.2 Types of clamping system

The clamping system opens and closes the mould, supports and carries the constituent parts of the mould, and generates sufficient force to prevent the mould from opening. Clamping force can be generated by a mechanical (toggle) lock, hydraulic lock, or a combination of the two basic types. [4]

2.3 Plasticizing unit

Today's plasticizing unit is almost exclusively an extruder that heats the cold plastic material to the required temperature to make it fluid for injection, or melt. The heating is generated mostly by the mechanical energy that created by the screw motor, as the extruder screw rotates in the barrel and works the plastic. This screw action also advances the plastic toward the tip of the screw.

Heaters around the barrel, usually in three or more heating zones, provide additional heating, which is mainly required during start-up of the machine but also where the mechanical working of the screw alone would not plasticize the amount of plastic required for each shot. [4]

2.4 Melt temperature

The melt temperature of the moulding material (stock temperature) is controlled by the barrel temperatures, screw speed, injection speed and back pressure. The water jackets around the barrel regulate the point at which the material will start to plasticize. The screw speed, injection speed and back pressure create frictional heat. To maintain a consistent and workable melt temperature, all of these variables must to be coordinated and adjusted. The stock temperature cannot be so hot that the material cures before it is able to fill the parts, nor so cold that the cycle times have to be extended in order for acceptable parts to be produced from the mould.

2.5 Injection pressure

The pressure on the material is controlled by the primary pressure, which moves the screw forward at a rapid speed to fill the cavities. The secondary pressure (holding pressure) finishes the filling of the cavities and maintains pressure on the material until it is sufficiently cured to allow the screw to return and plasticize the next shot. [4]

Plastic Injection pressure involves two stages. The first stage is, inject the melt plastic material into mould by a high speed, this pressure called first plastic injection pressure. We always called it plastic injection pressure too. Second stage is, the pressure we put after plastic material filled mould, called second plastic injection pressure or packing pressure.

2.6 Suitable materials

There are many types of materials that may be used in the injection moulding process. Most polymers may be used, including all thermoplastics, some thermosets, and some elastomers. When these materials are used in the injection moulding process, their raw form is usually small pellets or a fine powder. Also, colorants may be added in the process to control the colour of the final part. The selection of a material for creating injection moulded parts is not solely based upon the desired characteristics of the final part. While each material has different properties that will affect the strength and function of the final part, these properties also dictate the parameters used in processing these materials. Each material requires a different set of processing parameters in the injection moulding process, including the injection temperature, injection pressure, mould temperature, ejection temperature, and cycle time. A description and applications of some commonly used materials in the industry is shown below. [5]. Refer table 2.0.

Table 2.0: Example of materials used in injection moulding

NO.	Material name	Description	Applications
1.	Acetal (POM)	Strong, rigid, excellent fatigue resistance, chemical resistance, naturally opaque white, low/medium cost.	Bearings, cams, gears, handles, plumbing components and etc.
2.	Acrylic	Rigid, brittle, scratch resistant, transparent, optical clarity, low/medium cost.	Display stands, knobs, lenses, light housings and etc.
3.	Acrylonitrile Butadiene Styrene	Strong, flexible, low mould shrinkage (tight tolerances) and chemical resistance.	Automotive (consoles, panels, trim, vents), boxes and etc.
4.	Polycarbonate	Very tough, temperature resistance, dimensional stability, transparent and high cost.	Automotive (panels, lenses, consoles), bottles and etc.
5.	Polypropylene	Lightweight, heat resistance, high chemical resistance, scratch resistance, and low cost.	Automotive (bumpers, covers, trim) and etc.